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Effect of Additive to the Moisture Content at Different Decomposition Level of Peat

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Abstract The decomposition of peat soil is largely influence by its fiber content. The fiber has a high potential to retain water thus make peat soft and tender. The high water content owned by peat soil, is one of the reason of its easily compressible and low shear strength. Hydration water in soil was studied to understand the effect of additive in helping to reduce the water content of peat soil. Mixtures of peat soil with OPC and peat soil with bottom ash (BA) were tested using cone penetration limit method. The effect of BA in controlling peat water content was analyzed and compared with widely known hydration agent, ordinary portland cement (OPC). OPC was found to be effective to minimize the amount of water in peat soil. The hydration reaction between calcium in OPC with water to form C-S-H gel has lessen the amount of water in the mixture. On the other hand, the presence of BA does not show a significant decrease of water in the mixture. However, thixotropic effect was observed at day 3 for mixture of BA and peat soil at all decomposition level.

Keywords Peat, Ordinary portland cement (OPC), Bottom ash, Cone penetration, Moisture content, Thixotropic

1. Introduction

The decomposition of peat soil is largely influence by its fiber content. The less decompose will give a bigger size of fiber and known as fibric peat soil. The fiber has a high potential to retain water thus make peat soil soft and tender. The high water content owned by peat soil, is one of the reason of its easily compressible and low shear strength.

Fabric peat soil (F) generally retained more water, if compared to hemic (H) (moderately decomposed) and sapric (S) (most decomposed) peat soil. Thus, the amount of hydration agent should be applied to the peat soil must be differ. According to Mitchell and Soga (2005), there are three types of water that presence naturally in soil. Based on the binding forces acting on the water molecules in the soil matrix, soil–water can be classified into: 1) hydration water; 2) bound water; and 3) free water. Hydration water is chemically bound water which is an integral part of soil minerals. Bound water refers to those water molecules physically bound in the vicinity of soil particles (double layer) by adhesive forces. Free water is the loosely held water which is controlled by surface tensional forces and gravity. In conventional soil mechanics, pore water in the soil matrix is comprised of bound water and free water.

Hydration water in soil was studied to understand the effect of additive in helping to reduce the moisture content of peat soil. Additive that commonly use in peat soil treatment is ordinary portland cement (OPC). The hydration reaction between OPC and soils leads to initial gain in strength as the cementation product is formed due to drying up of water.

Bottom ash (BA) was introduced in this study to know its potential in controlling peat soil water content. BA is currently a waste product of coal power plant. Therefore, any usage of BA is considered as cost wise. Bottom ash is normally porous and contain high minerals especially quartz. The particle size is varies starting from as big as aggregates to the size of fine sand. The high value of silica and alumina in bottom ash is a key for pozzolan that will takes place with the presence of water and calcium hydroxide. Through x-ray fluoresence analysis, calcium presence in peat soil is around 0.54 % of total mass of dry peat soil. The effect of BA in controlling water content in peat soil is to be compared with widely known hydration agent, OPC.

2. Method

2.1. Peat Soil Sampling

Three types of peat soil was excavated at a maximum of 1.3 m depth at Pontian, Johor. Peat soil was physically and visually identified its decomposition level according to von post scale [2]. All samples were kept in tight container with plastic cover at the top of the peat soil to prevent moisture loss to the ambient. The containers were then placed in a curing chamber and ready for mixing step. A basic physical

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and chemical properties test of peat soil were conducted.

2.2. Preparation of Sample - Peat Soil

Three types of peat soil at different decomposition level namely fibric, hemic and sapric were used in this study. Wet peat was sieved passed through 2 mm sieve size. The peat was mixed thoroughly by hand for about 3 minutes. This was to ensure that only homogenous wet peat was used for mixing. The peat sample was mixed using food mixer at low speed for 1 minute followed by medium speed for another 4 minutes. The mixer was stopped and the material was scraped off the paddle and sides of the bowl before resuming mixing for another 3 minutes. This process was completed in duration of 8 minutes. EuroSoilStab (2002) suggesting 10 minutes of blending to achieved sufficiently uniform dispersion mixture. The peat was ready for mixing process.

2.3. Cement

The cement was first oven dried to ensure moisture free and kept in tight container. The amount of cement was calculated based on dry weight of peat soil.

2.4. Bottom Ash

Bottom ash (BA) was gained from local coal power plant at Pontian, Johor. Variety of sizes owned by BA was recorded, starting from aggregates to fine sand. BA was first oven dry at 105℃ for 24 hours. BA was then sieve at 2 mm and kept in airtight container. The 2 mm size and below was chosen to be used in this study because the BA still consist of porous materials and some may have pozzolan effect. Furthermore, bigger size may cause misleading of cone penetration reading as the cone might penetrate on the aggregates, not the mixture.

2.5. Mixing

The OPC or BA was added to the soils as per one scoop at a time. The mixture was first mix using hand before continue using food mixer for 5 minutes. The steps were repeat until all OPC or BA was fully mixed with the soils. The hydration process of cement is almost immediately and can last for 24 hours [3]. The mixture must be moulded into specific test specimen right after mixing before the cementation takes place where the sample hardens. The calculation of the mixture was based on the dry weight of soils (Eq. 1);

$$Mass\ of\ dry\ peat = \frac{Mass\ of\ water}{Moisture\ \ content} \tag{1}$$

It can be reverse calculated to find the mass of wet soils needed for the mixing as (Eq. 2);

$$M_1 = \left(\frac{Moisture\ \ content}{100} \times M_2\right) + \ M_2 \tag{2}$$

where;

M_1 = Mass of wet soils
M_2 = Mass of dry soils

The amount of OPC and BA used were based on dry mass of peat soil. The mixture of the samples prepared is as in Table 1.

Table 1. Mixing portion

Fabric, Hemic, Sapric	200 g of dry peat									
OPC, BA	5	10	15	20	25	30	35	40	45	50

2.6. Cone Penetration Test

Cone penetration test was used in this study to understand the mixture behaviour. The higher penetration recorded will represent the lower stiffness of the sample and vice versa. The samples were filled into cone penetration equipment for cone penetration test. The cone was penetrating into the sample and left for 5 seconds. The reading of penetration in cm was recorded. 3 consecutive reading were taken for each samples.

2.7. Moisture Content Tests

30 g of samples were taken out from mixture after one hour of mixing and heated at 105℃ for 6 hours. Samples were then weight. The different between the wet samples and dry samples will be calculated to find its moisture content. The moisture content was measured at Day 0 (D_0) and Day 3 (D_3) of the mixture.

3. Results and Discussions

3.1. Basic Physical and Chemical Properties of Peat and Hydration Agent

Basic physical and chemical properties were determined using simple laboratory test as in Table 2.

Table 2. Basic physico-chemical properties of peat and OPC

Properties	Samples					Standard
	Fabric	Hemic	Sapric	OPC	BA	
Moisture content (%)	883	393	602	Moisture free		BS1377 Part 2 :1990
Cone penetration (%)	321	184	255	-	-	BS1377Part 2 :1990
Specific gravity	1.10	1.58	1.18	1.26	2.30	BS1377Part 2 :1990
Fiber content (%)	68.2	37.6	21.0	-	-	ASTM D1997-91
pH	3.27	3.82	3.37	12.3	9.17	BS1377Part 2 :1990
Loss of Ignition	0.97	0.97	0.97	-	-	BS1377Part 2 :1990
Bulk Density	9.20	9.21	9.21	-	-	BS1377Part 2 :1990

3.2. Effect of Additive to the Peat at Different Decomposition Level

The cone penetration test has been conducted to all types of mixtures. All mixtures were tested for D_0 and D_3. D_0 was chosen to look into the fresh condition before any reactions take place. Horpibulsuk found that fewer than 7 days, only early stage of hydration happens [4]. This is the reason of considering curing times when a study on soil stabilization is to be conducted. While D_3 was chosen as to look into hydration effect if there is any. The patterns of the stiffness of mixture for all three types of peat (Fig.1) with OPC and BA were compared.

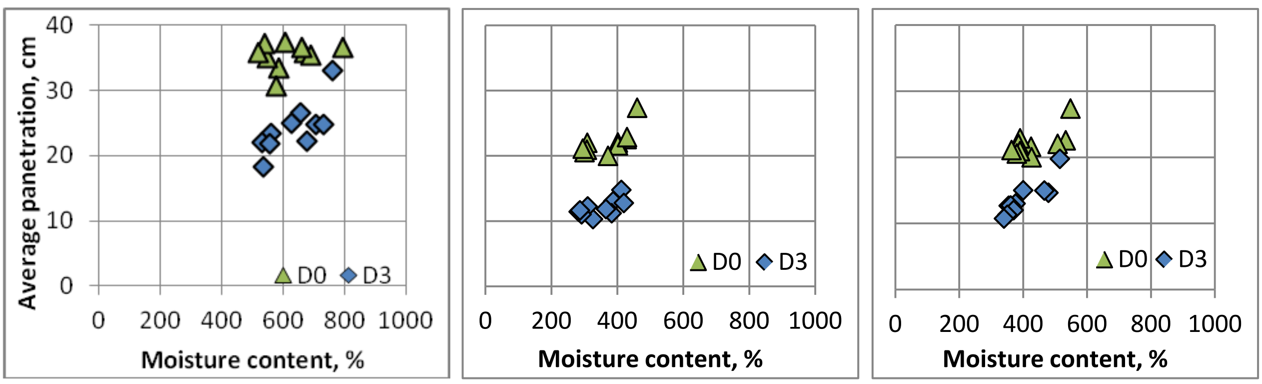
All three types of peat, when mixed with OPC have loss its water content. This is due to hydration process. The main product of hydration is $Ca(OH)_2$ where calcium was gained from the OPC while OH is the part of the water in the soil, particularly peat. The consumption of the water to produced $Ca(OH)_2$ which also known as C-S-H gel effect the stiffness of the mixture. The higher amount of C-S-H gel present the lower the penetration values.

Generally, increment of 5 % of OPC in the mixture did not give any significant trend. The cone penetration and moisture content reading shows that there are ranges for the mixtures. All treated samples were found stiffer at D_3 if compared with D_0.

For fabric peat, the range of penetration at D_0 was found at 30 - 40 cm while at D_3 it reduces to 17 - 27 cm. The water content for fabric peat was initially high which is 883 %. The high amount of water gives a scatter pattern to the cone penetration test.

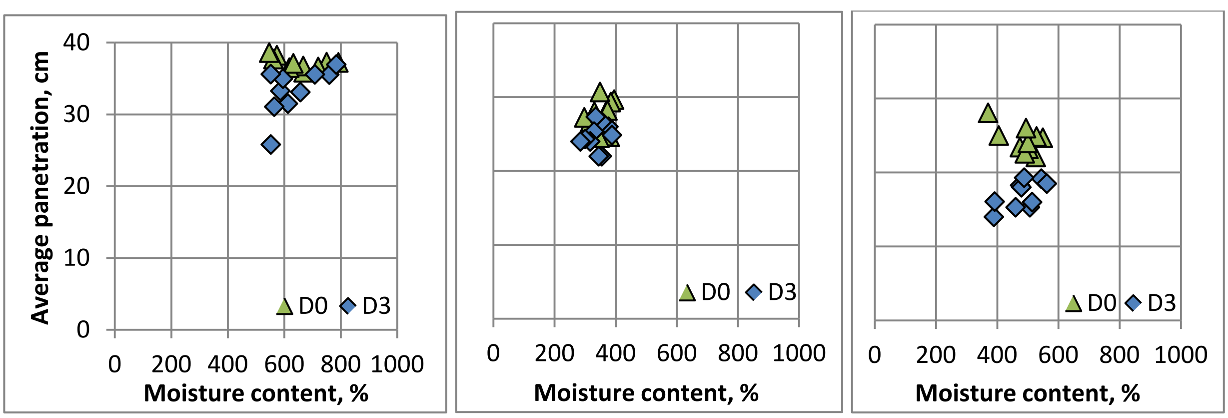
Unlike fabric peat, hemic peat shows more uniform reading for all types of mixtures. At D_3, all cone penetration gives typical reading with ranges of 10 - 15 cm of penetration at moisture content of 250 - 450 %. This is mainly because of the low moisture content of hemic peat which is 393 %. Less water can be consumed to form C-S-H gel resulting not much different in reading even for increasing amount of OPC in the mixtures.

Sapric peat, with moisture content of 602 %, shows almost same pattern with hemic peat at D_0. A different in pattern can be seen for D_3 where the penetration of the mixtures has a wide range, which is 6 - 19 cm. The moisture content was found lessen at D_3 with the range of 350 - 550 %. As the initial moisture content of sapric peat is moderate, the water to be consumed by calcium in OPC is there. It is the main key to understand the reason of variety of stiffness recorded by cone penetration test.



Fabric Hemic Sapric

Figure 1. Average penetration for mixture of peat and OPC



Fabric Hemic Sapric

Figure 2. Average penetration for mixture of peat and BA

Bottom ash, as a porous material, may provide spaces for water and soil particles to be trapped in. The stiffness of the mixtures (Fig. 2) were found to be affected a bit with the presence of bottom ash but the moisture content of the mixture, even at D_3 was found at almost the same value with reading recorded at D_0.

No hydration reaction occurs that consume the water in the peat. The dehydration process, which is defined as loss of water to environment was also at minimum percentage. The stiffness gained by the mixtures explains the possibility of BA to fill the porous void within peat fiber. Some finer particles of peat also may fill the porous spaces in BA as in Fig. 3. This shows that BA is not a dehydration agent but may act as filler in soil treatment.

The pozzolanic reaction which resulting in strengthening the soil skeleton [5] may occur with the presence of BA in peat but the longer curing times is needed to confirm such reaction which normally 28 days.

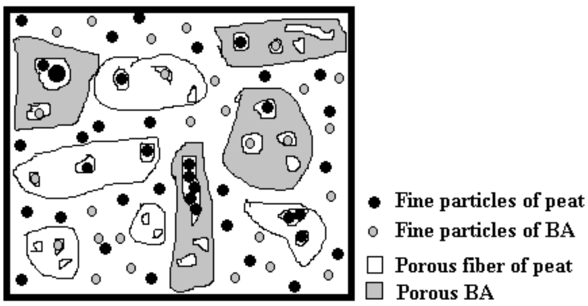
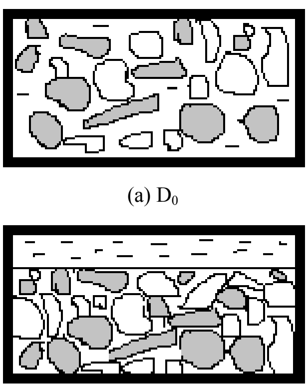


Figure 3. Illustration of fine particles filling porous spaces in BA and peat



(a) D_0

(b) D_3

Figure 4. Illustration of peat-BA mixture

Thixotropy effect was observed in mixture of peat and BA. In geotechnical engineering, thixotropic hardening is, after softening by remolding, the process of time-dependent return to a harder state under constant water content or volume conditions [6]. As the finer particles in peat filling the porous spaces in bottom ash, the cured samples were found higher in density. Self compaction of particles in the mixtures happens due to gravitational force which pushes the less dense water to the upper part of the container (Fig.4). When sample of mixture of peat-BA was open at D_3, water can be observed clearly. A few drops of water was normally comes out easily from the container. This phenomenon is known as bleeding. This answer the stiffer mixture gained on D_3 even though no reaction occurs between peat and BA.

4. Summary

The reaction between OPC and hydration water in peat shows that OPC is always the most practical additive for controlling water content during peat treatment. As for comparison, BA is not suitable to be used as dehydration agent but it is good to work as filler. The pozzolanic reaction may happen when peat is mix with BA but the study should be extend to 28 days to confirm the hypothesis.

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